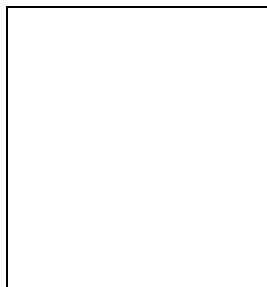


B PHYSICS AT DØ

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The DØ detector at FNAL has undergone a significant upgrade for its present Run II data taking period, allowing for a broad B physics programme. This report focuses on studies performed on a sample of approximately $75 \cdot 10^3$ inclusive J/ψ events. Preliminary results on mass and lifetime measurements and prospects for flavour tagging are presented.

1 Introduction

The high integrated luminosity expected to be delivered at Run II make the Tevatron $p\bar{p}$ collider an ideal environment for the study of a wide range of physics processes. In particular, the high inclusive b production cross section allows a precise study of many relatively rare B hadron decay modes. The copious production of B_s mesons opens up a rich field of B physics studies not accessible at e^+e^- B factories. As presented previously in this meeting series¹, the DØ detector has been upgraded significantly to take advantage of these physics opportunities.

2 Data sample

The data presented here represent an integrated luminosity of approximately 40pb^{-1} , and were collected using di-muon triggers and pre-selected requiring two muons reconstructed in the muon system within $|\eta| < 2.4$. The invariant mass distribution of pairs of oppositely charged muons, as shown in Fig. 1, indicates approximately $75 \cdot 10^3$ inclusive $J/\psi \rightarrow \mu^+\mu^-$ events. Given the preliminary calibration of the detector, the average observed mass is in reasonable agreement with the nominal J/ψ mass². Using this J/ψ sample, various exclusive B decays ($B^\pm \rightarrow J/\psi K^{(*)\pm}$, $B_d \rightarrow J/\psi K^{*0}$, and $B_d \rightarrow J/\psi K_S$) have been identified. The mass distribution of $J/\psi K^\pm$ events, used extensively later in this report, is also shown in Fig. 1.

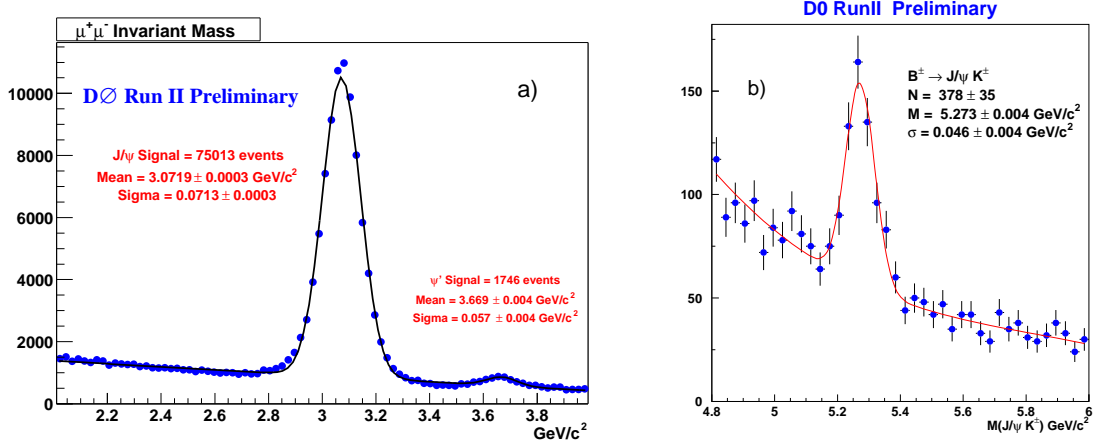


Figure 1: Invariant mass distribution of pairs of oppositely charged muons (a) and of $J/\psi K^\pm$ candidates (b).

3 χ_c production

The collected sample of inclusive J/ψ events is used to study χ_c production through its radiative decay $\chi_c \rightarrow J/\psi \gamma$. As low energy photons are not easily identified in the DØ calorimeter, they are instead identified by their photoconversions in the beam pipe and (mainly) in the detector materials. With a kinematic cut $p_{T,\gamma} > 1$ GeV/c, from Monte Carlo computations the photon reconstruction efficiency is estimated to be approximately 0.37%.

The photons thus reconstructed are combined with the found J/ψ candidates. The mass difference resolution is insufficient to resolve the individual χ_c resonances, and in the fit the difference between the χ_{c1} and χ_{c2} masses is therefore fixed to its nominal value while their relative contribution to the peak is allowed to float (the $\chi_{c0} \rightarrow J/\psi \gamma$ branching ratio is too small to contribute appreciably to the observed peak). The resulting number of candidates, corrected for the photon reconstruction efficiency and compared with the number of J/ψ candidates, leads to an estimated fraction $F_\chi^{J/\psi}$ of J/ψ originating from χ_c decays

$$F_\chi^{J/\psi} = 0.030 \pm 0.04(\text{stat.}), \quad (1)$$

in good agreement with the Run I result from the CDF Collaboration³ and in marked disagreement with predictions from colour singlet models.

4 B Lifetime

The inclusive J/ψ events are used in two ways to perform B lifetime measurements: once in an inclusive measurement, and once in an exclusive $B^\pm \rightarrow J/\psi K^\pm$ measurement. In both cases, the decay lengths are estimated from the measured secondary vertex coordinates in the plane transverse to the beam line, corrected using the B hadron p_t through $(ct)_B = \lambda_B = L_{xy} m_B / p_t^B$.

4.1 Inclusive measurement

In the inclusive measurement, the B hadron is not fully reconstructed so that the quantity m_B / p_t^B is not known from event to event. It is therefore obtained as an average correction factor, as a function of the p_t of the J/ψ . The correction factor is computed using the Pythia Monte Carlo generator⁴, with the B hadron decays simulated by the QQ program⁵, and is displayed in Fig. 2(a). The proper decay length distribution of the J/ψ background is obtained

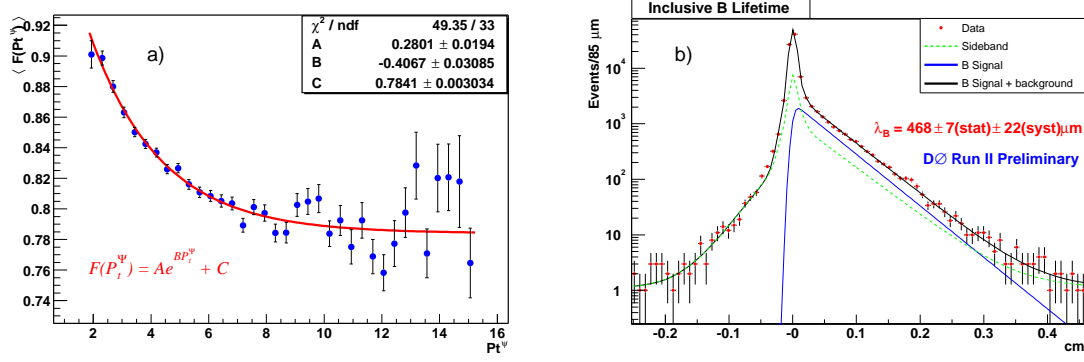


Figure 2: J/ψ p_t correction factor in the inclusive J/ψ lifetime analysis (a), and proper decay length distribution (b).

from the J/ψ sideband windows ($2.6 \text{ GeV} < m_{\mu\mu} < 2.85 \text{ GeV}$ and $3.29 \text{ GeV} < m_{\mu\mu} < 3.5 \text{ GeV}$), and fit to a double Gaussian resolution function and the sum of an exponential plus a constant background. This background is fixed in the J/ψ signal window, and a prompt component and signal exponential convoluted with the resolution function obtained from the sideband windows is added. The signal window decay length distribution, along with its fit, is shown in Fig. 2(b). The systematic uncertainty on the average lifetime is dominated by uncertainties on the correction factor applied ($16 \mu\text{m}$, mainly from fragmentation uncertainties) and fit biases ($13 \mu\text{m}$, as determined from Monte Carlo studies). The average lifetime is therefore determined to be

$$\tau_B = (1.561 \pm 0.023(\text{stat.}) \pm 0.073(\text{syst.}))\text{ps}, \quad (2)$$

in good agreement with the world average result.

4.2 B^\pm lifetime

The use of fully reconstructed B hadrons allows to estimate the B hadron momentum on an event by event basis and has lower background, and therefore leads to a much reduced systematic lifetime uncertainty. A sample of B^\pm mesons is obtained through their decay $B^\pm \rightarrow J/\psi K^\pm$, where (in the absence of π/K separation) charged particles compatible with originating from the J/ψ vertex are assigned the kaon mass.

The background to the lifetime distribution in this case consists of two components: incompletely reconstructed B decays mainly populating the lower B^\pm sideband region, and prompt combinatorial background. The lifetime of the former is determined and fixed in the fit to the signal region, while its fraction is fixed to expectations from Monte Carlo. The B^\pm signal window is fit to this background plus an exponential signal component convoluted with a Gaussian resolution function. The result of the fit is

$$\tau_{B^\pm} = (1.761 \pm 0.24(\text{stat.}))\text{ps}, \quad (3)$$

within its large uncertainty again in agreement with the world average result.

5 Flavour tagging

The measurement of mixing and CP violation in neutral B meson decays, a crucial part of the Tevatron B physics programme, involves tagging the B meson's flavour at its time of production. The use of reconstructed B^\pm mesons allows to determine the performance of such flavour tags in an unbiased way.

In opposite side tags, the charge of the B meson of interest at its time of production is estimated by considering the charge of the B hadron produced in association with it. Two such tags have been studied within the DØ Collaboration. In the soft muon tag, the charge of the highest p_t muon (with $p_t > 1.9$ GeV/ c) in the event is considered, requiring a separation from the signal B meson $\Delta R > 2$. The jet charge tag considers the p_t weighted charge average Q of the tracks separated from the B meson in azimuth by $|\Delta\phi| > 2$ and associated with the primary vertex within 2 cm. A jet is considered tagged if $|Q| > 0.2$.

The performance of the tags is characterised by factor ϵD^2 , where ϵ is the tagging efficiency and the “dilution” D is given by $D = 1 - 2P_w$, with P_w being the fraction of wrongly tagged jets. The “raw” efficiency and dilution, as obtained from the B^\pm signal region, are corrected for the background under the B^\pm peak using the corresponding numbers as obtained from the B^\pm sideband windows. The corrected results are shown in Table 1 and are in reasonable agreement with expectations⁶.

Tag	soft muon	jet charge
efficiency ϵ (%)	8.2±2.2	55.1±4.1
dilution D (%)	63.9±30.1	21.1±10.6
ϵD^2 (%)	3.3±1.8	2.4±1.7

Table 1: Flavour tagging performance estimates.

Conclusions

Using a large sample of inclusive J/ψ events collected from an integrated luminosity of about 40 pb⁻¹, the DØ Collaboration has searched for resonances decaying to $J/\psi X$. Preliminary B hadron lifetime measurements are in reasonable agreement with world average results. $B^\pm \rightarrow J/\psi K^\pm$ decays have been used to demonstrate that DØ’s flavour tagging performance is in agreement with predictions made before the start of the Tevatron Run II.

Improvements are ongoing in the DØ detector performance, data collection efficiency, and data reconstruction software programs. Together with the increasing luminosity of the Tevatron collider, substantial improvements in the results presented here are foreseen, as well as many qualitatively new results.

Acknowledgements

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